# SOURCE TEST REPORT

06-249

**CONDUCTED AT**

BP/ARCO Refinery
1801 E. Sepulveda Blvd.
Carson, California 90749

PARTICULATE MATTER (PM), VOLATILE ORGANIC COMPOUND (VOC), SPECIATED HYDROCARBONS, AROMATIC HYDROCARBONS, AND SULFUR COMPOUNDS EMISSIONS FROM A COKE DRUM STEAM VENT

| | |
|---|---|
| **TESTED:** | August 2 & 8, 2006 |
| **LAB DATA COMPLETED:** | February 1, 2008 |
| **ISSUED:** | February 20, 2008 |
| **REPORTED BY:** | Carey Willoughby<br>Air Quality Engineer II |

**REVIEWED BY:**

Michael Garibay
Supervising Air Quality Engineer

**SOURCE TEST ENGINEERING**

**MONITORING AND ANALYSIS**

## ***SUMMARY***

| | | |
|---|---|---|
| a. | Firm | BP/ARCO Refinery |
| b. | Site Location | 1801 E. Sepulveda Blvd., Carson CA 90505 |
| c. | Mailing Address | 1801 E. Sepulveda Blvd., Carson CA 90505 |
| d. | Unit Tested | Petroleum Coke Drums No. 2 & No. 3 |
| e. | Requested by | Eugene Teszler, A.Q. Specialist; Planning, Rule Development & Area Sources (909) 396-2077 |
| f. | Reason for Test Request | Rule Development Information |
| g. | Date of Test | August 2 & 8, 2006 |
| h. | Source Test Performed by | M. Garibay, C. Willoughby W. Stredwick, R. Lem |
| i. | Test Arrangements Made through | Joshua Lipscomb, (310) 816-8631 Environmental Process Engineer |
| j. | Source Test Observed by | Joshua Lipscomb, (310) 816-8631 Eugene Teszler, (909) 396-2077 |
| k. | Company ID. No. | 800012 |

***RESULTS***

**Table 1**
**SCAQMD Rules (Blowdown)**
**Flow Rate 3.68 dscmm (130 dscfm)**
**Process Rate 30,300 kg/hr (66,900 lb/hr)**

| Contaminant | Measured | Allowed | Applicable Rule |
|---|---|---|---|
| **Particulate Matter (PM)** | | | |
| **Concentration (Total PM)** | **6,030 mg/dscm (2.63 gr/dscf)** | **450 mg/dscm (0.196 gr/dscf)** | **404(a)** |
| **Mass Rate (Solid PM)** | **1.13 kg/hr (2.49) lb/hr** | **7.04 kg/hr (15.5) lb/hr** | **405(a)** |
| **Sulfur Compounds as $H_2S$** | **7,710 ppm** | **500 ppm** | **407(a)(2)(A)** |

**Table 2**
**Mass Emissions Per Single Drum Blow Down Event**

| Contaminant | Physical Description of Sample | Measured |
|---|---|---|
| **Solid PM from SCAQMD Method 5.1** | **Solid Fine Material with Coke Dust Appearance** | **3.77 lb** |
| **Condensable Organic PM/VOC* from SCAQMD Method 5.1** | **Liquid Hydrocarbon** | **0.66 lb** |
| **Gaseous VOC as Hexane from Canister Following SCAQMD Method 5.1 Sampler** | **Gaseous Phase Hydrocarbon Primarily $C_3$-$C_8$** | **4.44 lb** |
| **Sulfur Compounds as $H_2S$** | **Primarily $H_2S$** | **8.18 lb** |

* This organic portion of the SCAQMD Method 5.1 sample meets both the SCAQMD Rule 102 definitions for PM and VOC.

***RESULTS CONTINUED***

**Table 3**
**SCAQMD Rules (Steaming)**
**Flow Rate 9.40 dscmm (332 dscfm)**
**Process Rate 30,300 kg/hr (66,900 lb/hr)**

| Contaminant | Measured | Allowed | Applicable Rule |
|---|---|---|---|
| **Particulate Matter (PM)** | | | |
| **Concentration (Total PM)** | **560 mg/dscm (0.244 gr/dscf)** | **450 mg/dscm (0.196 gr/dscf)** | **404(a)** |
| **Mass Rate (Solid PM)** | **0.30 kg/hr (0.66) lb/hr** | **7.04 kg/hr (15.5) lb/hr** | **405(a)** |
| **Sulfur Compounds as $H_2S$** | **0.07 ppm** | **500 ppm** | **407(a)(2)(A)** |

**Table 4**
**Mass Emissions Per Single Drum Steaming Event**

| Contaminant | Physical Description of Sample | Measured |
|---|---|---|
| **Solid PM from SCAQMD Method 5.1** | **Solid Fine Material with Coke Dust Appearance** | **0.080 lb** |
| **Condensable Organic PM/VOC* from SCAQMD Method 5.1** | **Liquid Hydrocarbon** | **0.0043 lb** |
| **Gaseous VOC as Hexane from Canister Following SCAQMD Method 5.1 Sampler** | **Gaseous Phase Hydrocarbon Primarily $C_3$-$C_8$** | **0.00097 lb** |
| **Sulfur Compounds as $H_2S$** | **Primarily $H_2S$** | **0.00002 lb** |

* This organic portion of the SCAQMD Method 5.1 sample meets both the SCAQMD Rule 102 definitions for PM and VOC.

***RESULTS CONTINUED***

**Table 5**
**Speciated Gaseous Emissions (Blowdown)**
**Flow Rate 3.68 dscmm (130 dscfm)**

| Contaminant | Tank 54180 | Tank P4M3 | Average |
|---|---|---|---|
| **VOC** | | | |
| **-Concentration as C (ppm)** | **10000** | **9840** | **9920** |
| **-Mass Rate (lb/hr)** | **2.94** | **2.90** | **2.92** |
| **Methane** | | | |
| **-Concentration (percent)** | **34.6** | **31.5** | **33.0** |
| **-Mass Rate (lb/hr)** | **0.01** | **0.01** | **0.01** |
| **Ethane** | | | |
| **-Concentration (ppmC)** | **29800** | **27300** | **28550** |
| **-Mass Rate (lb/hr)** | **9.19** | **8.43** | **8.81** |
| **$C_3$** | | | |
| **-Concentration (ppm)** | **470** | **464** | **467** |
| **-Mass Rate (lb/hr)** | **0.43** | **0.42** | **0.42** |
| **$C_4$** | | | |
| **-Concentration (ppm)** | **68.4** | **67.8** | **68.1** |
| **-Mass Rate (lb/hr)** | **0.08** | **0.08** | **0.08** |
| **$C_5$** | | | |
| **-Concentration (ppm)** | **32.3** | **31.3** | **31.8** |
| **-Mass Rate (lb/hr)** | **0.05** | **0.05** | **0.05** |
| **$C_6$** | | | |
| **-Concentration (ppm)** | **14.4** | **13.4** | **13.9** |
| **-Mass Rate (lb/hr)** | **0.03** | **0.02** | **0.02** |
| **$C_7$** | | | |
| **-Concentration (ppm)** | **328** | **341** | **334** |
| **-Mass Rate (lb/hr)** | **0.67** | **0.70** | **0.69** |
| **$C_8$** | | | |
| **-Concentration (ppm)** | **399** | **418** | **408** |
| **-Mass Rate (lb/hr)** | **0.94** | **0.98** | **0.96** |

***RESULTS CONTINUED***

**Table 5 Continued**
**Speciated Gaseous Emissions (Blowdown)**
**Flow Rate 3.68 dscmm (130 dscfm)**

| Contaminant | Tank 54180 | Tank P4M3 | Average |
|---|---|---|---|
| **$C_{9-12}$** | | | |
| **-Concentration (ppm)** | **242** | **253** | **247** |
| **-Mass Rate (lb/hr)** | **0.74** | **0.78** | **0.76** |
| **Benzene** | | | |
| **-Concentration (ppm)** | **379** | **393** | **386** |
| **-Mass Rate (lb/hr)** | **0.61** | **0.63** | **0.62** |
| **Toluene** | | | |
| **-Concentration (ppm)** | **461** | **481** | **471** |
| **-Mass Rate (lb/hr)** | **0.87** | **0.91** | **0.89** |
| **Ethyl Benzene** | | | |
| **-Concentration (ppm)** | **14.8** | **12.7** | **13.8** |
| **-Mass Rate (lb/hr)** | **0.03** | **0.03** | **0.03** |
| **m+p-Xylene** | | | |
| **-Concentration (ppm)** | **171** | **177** | **174** |
| **-Mass Rate (lb/hr)** | **0.37** | **0.39** | **0.38** |
| **o-Xylene** | | | |
| **-Concentration (ppm)** | **22.1** | **18.7** | **20.4** |
| **-Mass Rate (lb/hr)** | **0.05** | **0.04** | **0.04** |
| **CO** | | | |
| **-Concentration (ppm)** | **1080** | **978** | **1029** |
| **-Mass Rate (lb/hr)** | **0.62** | **0.56** | **0.59** |

***RESULTS CONTINUED***

**Table 6**
**Speciated Gaseous Emissions (Steaming)**
**Flow Rate 9.40 dscmm (332 dscfm)**

| Contaminant | Tank 54154 | Tank 54209 | Average |
|---|---|---|---|
| **VOC** | | | |
| **-Concentration as C (ppm)** | **12** | **9** | **10.5** |
| **-Mass Rate (lb/hr)** | **0.009** | **0.008** | **0.008** |
| **Methane** | | | |
| **-Concentration (percent)** | **8** | **4** | **6** |
| **-Mass Rate (lb/hr)** | **0.007** | **0.003** | **0.005** |
| **Ethane** | | | |
| **-Concentration (ppmC)** | **2** | **<1** | **<1.5** |
| **-Mass Rate (lb/hr)** | **0.002** | **< 0.001** | **< 0.001** |
| **$C_3$** | | | |
| **-Concentration (ppm)** | **0.4** | **0.2** | **0.3** |
| **-Mass Rate (lb/hr)** | **0.0008** | **0.0004** | **0.0007** |
| **$C_4$** | | | |
| **-Concentration (ppm)** | **0.3** | **<0.1** | **<0.2** |
| **-Mass Rate (lb/hr)** | **0.001** | **< 0.0003** | **< 0.0006** |
| **$C_5$** | | | |
| **-Concentration (ppm)** | **0.2** | **0.1** | **0.15** |
| **-Mass Rate (lb/hr)** | **0.001** | **0.0003** | **0.0006** |
| **$C_6$** | | | |
| **-Concentration (ppm)** | **0.2** | **0.2** | **0.2** |
| **-Mass Rate (lb/hr)** | **0.001** | **0.001** | **0.0009** |
| **$C_7$** | | | |
| **-Concentration (ppm)** | **0.3** | **0.2** | **0.25** |
| **-Mass Rate (lb/hr)** | **0.002** | **0.001** | **0.001** |
| **$C_8$** | | | |
| **-Concentration (ppm)** | **0.3** | **0.2** | **0.25** |
| **-Mass Rate (lb/hr)** | **0.002** | **0.001** | **0.001** |

***RESULTS CONTINUED***

**Table 6 Continued**
**Speciated Gaseous Emissions (Steaming)**
**Flow Rate 9.40 dscmm (332 dscfm)**

| Contaminant | Tank 54154 | Tank 54209 | Average |
|---|---|---|---|
| **$C_{9-12}$** | | | |
| **-Concentration (ppm)** | **1.0** | **0.4** | **0.7** |
| **-Mass Rate (lb/hr)** | **0.008** | **0.003** | **0.005** |
| **Benzene** | | | |
| **-Concentration (ppm)** | **<0.1** | **<0.1** | **<0.1** |
| **-Mass Rate (lb/hr)** | **< 0.0004** | **< 0.0004** | **< 0.0004** |
| **Toluene** | | | |
| **-Concentration (ppm)** | **<0.1** | **<0.1** | **<0.1** |
| **-Mass Rate (lb/hr)** | **< 0.0005** | **< 0.0004** | **< 0.0005** |
| **Ethyl Benzene** | | | |
| **-Concentration (ppm)** | **<0.1** | **<0.1** | **<0.1** |
| **-Mass Rate (lb/hr)** | **< 0.0006** | **< 0.0006** | **< 0.0005** |
| **m+p-Xylene** | | | |
| **-Concentration (ppm)** | **<0.1** | **<0.1** | **<0.1** |
| **-Mass Rate (lb/hr)** | **< 0.0006** | **< 0.0006** | **< 0.0006** |
| **o-Xylene** | | | |
| **-Concentration (ppm)** | **<0.1** | **<0.1** | **<0.1** |
| **-Mass Rate (lb/hr)** | **< 0.0006** | **< 0.0006** | **< 0.0006** |
| **CO** | | | |
| **-Concentration (ppm)** | **2** | **<1** | **<1.5** |
| **-Mass Rate (lb/hr)** | **0.003** | **< 0.001** | **< 0.002** |

## ***INTRODUCTION***

On August 2 & 8, 2006, personnel from the South Coast Air Quality Management District (SCAQMD) Source Test Engineering Branch conducted testing at the BP/ARCO Refinery in Carson. The purpose of the test was to measure the VOC, speciated hydrocarbon, aromatic hydrocarbon, particulate matter, and sulfur compound emissions at the exhaust steam vent following the steaming and blow down stages of the coking process from coke drum numbers 3 and 2 respectively. The volumetric flow rate was also determined so that the measured concentrations could be reported in terms of mass emission rates. The testing was requested by the SCAQMD Planning and Rule Development Division for purposes of collecting coker unit emissions information for potential rule development.

## ***EQUIPMENT AND PROCESS DESCRIPTION***

BP/ARCO has 6 delayed cokers at its Carson refinery. Each drum is approximately 21 feet in diameter and 73 feet in height. The coker drums are containers which allow the resid feed material (bottoms product of the crude unit) sufficient residence time to crack thermally and produce coke and other products. In addition to resid, other feeds including sludge, oily wastes, etc. are processed in cokers. Figure 1 diagrams the delayed coker process flow.

Resid feed (~ 400 $^{o}$F) is combined with the main fractionation (combination) tower products. The fractionation tower products transfer heat to the resid feed, raising temperatures by 100-150 $^{o}$F. The combined effluent cools slightly, condensing the heaviest components, while the lighter products rise up in the tower. The heavy feed combined with the effluent recycle leave the bottom of the fractionation tower, are mixed with steam, pass through a furnace, and flow into the bottom of an emptied coke drum. The steam ensures that the feed velocity remains high while moving through the furnace, and minimizes any coking occurring in the furnace. The feed temperature exiting the furnace is 910-930 $^{o}$F; the pressure is 30 - 60 psig.

The coke feed resides in the drum under high temperature as the reactions continue. During the coking process, hydrocarbon molecules “crack” into smaller molecules which rise and leave the top of the coke drum as vapors. The material left behind condenses and polymerizes to solid coke. More feed and steam is forced through the solidifying coke, creating pores in the structure, and giving the coke a sponge-like appearance. When the coke level rises to the fill point, the feed is directed to a second drum.

Hydrocarbon vapors leaving the coke drum flow to the fractionator tower, with the heaviest components being recycled. Recycle rates vary from 5 to 50% depending on how much coke is desired. A minimum recycle is required to minimize contamination of the heavy gas oil with coke fines and heavier materials. Products from the coker include naphtha (light and heavy), light gas oil, heavy gas oil and sometimes kerosene.

Following around 18 hours of coking, the drum is steamed for an hour to convert any remaining wet resid to coke. Next, cooling (quench) water is injected into the bottom of the drum. The cooling water carries any entrained hydrocarbons through the drum as it turns to steam, and cools the drum down gradually. During the blowdown period, the cooling water is drained, and the coke drum is depressurized (steam released) before the heads are taken off the top and bottom of the drum. Source testing was performed during the depressurization stage at the steam vent.

Coke is removed from the drum using a stream of high pressure (1000-2000 psi) water. The water flows down a drill stem into a cutter head, which directs high pressure water in a downwards spiraling manner. After drilling a pilot hole through the center, the water pressure is directed sideways, breaking the coke into chunks. The coke chunks fall through the pilot hole into a coke storage pit, or directly into a crusher car. The crusher car breaks larger pieces of coke

into more manageable pieces. The coke is transferred/conveyed into enclosed storage piles or loaded onto railroad cars.

A typical delayed coker drum cycle consists of 16-18 hours of coking, followed by the coke removal process. Following coke removal, the head is replaced, the system is purged of air using steam while also re-heating the drum in preparation for the next batch. Source testing was also performed during this steaming stage at the steam vent. This post coke removal portion of the process can take approximately 5 hours.

**Source Test Operating Conditions Drum #2:**

| | |
|---|---|
| Coke Production: | 535 ton/batch (16-hour cycle) |
| Blow Down Time: | 1 ½ hr |
| Drum Pressure During Blowdown: | 0.89 psig |
| Drum Outage (Fill Distance from Top): | 34 ft |
| Feed Temperature @ end of test: | 211$^{o}$ F |
| Exit Temperature @ end of test: | 151$^{o}$ F |
| Drum Size: | 21 ft – 6 in diameter x 73 ft height |

**Source Test Operating Conditions Drum #3:**

| | |
|---|---|
| Coke Production: | 535 ton/batch (16-hour cycle) |
| Steaming Time: | 7 min 20 sec |
| Drum Pressure During Steaming: | 0.1 psig |
| Drum Outage (Fill Distance from Top): | 33 ft |
| Feed Temperature @ end of test: | 93$^{o}$ F |
| Exit Temperature @ end of test: | 212$^{o}$ F |
| Drum Size: | 21 ft – 6 in diameter x 73 ft height |

*For more process information, please refer to the BP/ARCO letter in the Appendix.*

## *SAMPLING AND ANALYTICAL PROCEDURES*

### *Gas Flow Rate*

The exhaust gas velocity was measured using a Standard type Pitot tube with a differential pressure manometer. The temperature was measured using a type "K" thermocouple with a digital potentiometer. The exhaust flow rate was calculated from the average gas velocity and duct cross-sectional area. The flow rate was corrected to dry standard conditions based on the gas stream moisture content (SCAQMD Method 4.1 weight gain from the particulate train), temperature and barometric pressure. The port location was at least one half stack diameter upstream and greater than eight duct diameters downstream from any flow disturbances along the ten inch diameter horizontal exhaust duct. For the Blowdown test, the emissions continued after the sampling was completed. To incorporate the post sampling emissions, a reference point velocity was taken at 5 minute intervals after the sampling was completed. Since the reference point during the traverse (157 ft/min) was similar to the post sampling average velocity (150 ft/min), it was assumed that the emissions continued at the same rate for the entire venting period.

### *Particulate Sampling*

SCAQMD Method 5.1 train was used, modified (Figure 2) by the addition of a cooling coil (in an ice bath) following the probe and followed by the addition of five empty bubblers (Greenberg-Smith impingers with tips replaced with a 1.3 cm id. glass tube extending to about 1.3 cm from the bottom of each flask). The remainder of the sample train was arranged in accordance with Method 5.1 which included the stainless steel nozzle and probe, two impingers, each filled with 100 ml of deionized water, an empty bubbler, fiberglass filter, and a bubbler filled with tared silica gel. The modified train was connected to a leak-free vacuum pump, dry gas meter, and calibrated orifice. The impingers were contained in an ice bath to condense water vapor and other condensable matter contained in the sample stream.

### *Integrated Gas Sampling – Total Gaseous Non-Methane Non-Ethane Organics and Sulfur Compounds*

Duplicate canisters (6L) were used to collect exhaust stream gas samples. The gas was sampled from a slip stream off the modified Method 5.1 train, located after the fiberglass filter but before the silica gel bubbler (Figure 2). SCAQMD's laboratory analyzed the collected samples for carbon monoxide, carbon dioxide, ethane, and non-methane non-ethane organic compounds (NMNEOC) using SCAQMD Method 25.1 (TCA FID, no trap). Hydrocarbon speciation, benzene, toluene and xylene analyses were done by cryo-GC FID. Additionally a Method 10.1 (GC TCD) analysis was performed to determine the concentrations of hydrogen, nitrogen, methane and oxygen.

A second type of integrated gas sample was also collected continuously from a slip stream off the modified Method 5.1 train, located after the fiberglass filter but before the silica gel bubbler (Figure 2). The gas sampling apparatus consisted of a stainless steel probe, peristaltic pump, and Tedlar gas sampling bag. The sampled gas was analyzed for sulfur compounds by SCAQMD Method 307-91, SCD350A, Capillary Column, Flameless Interface.

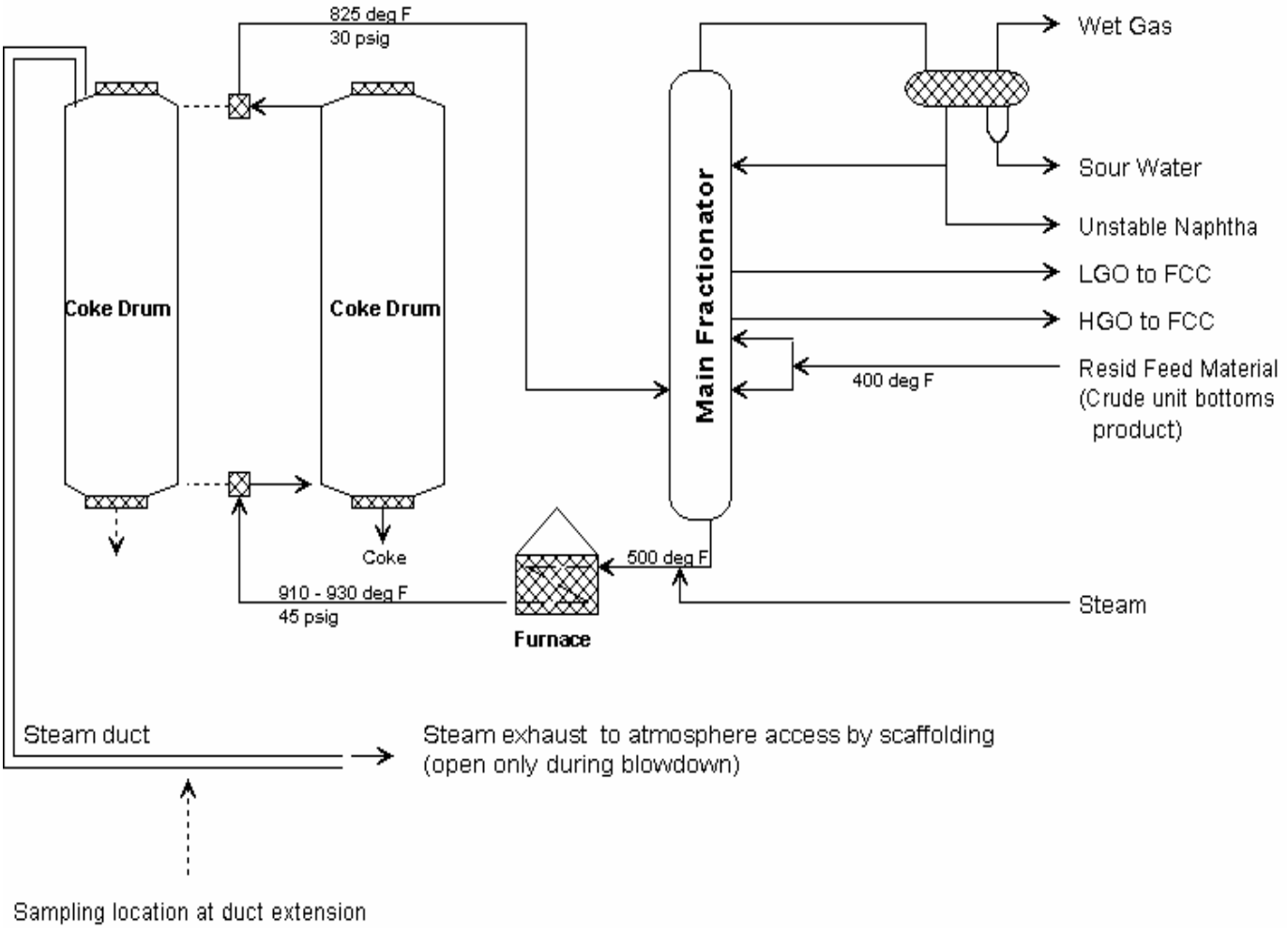


**Figure 1**
**Delayed Coker Flow Diagram**

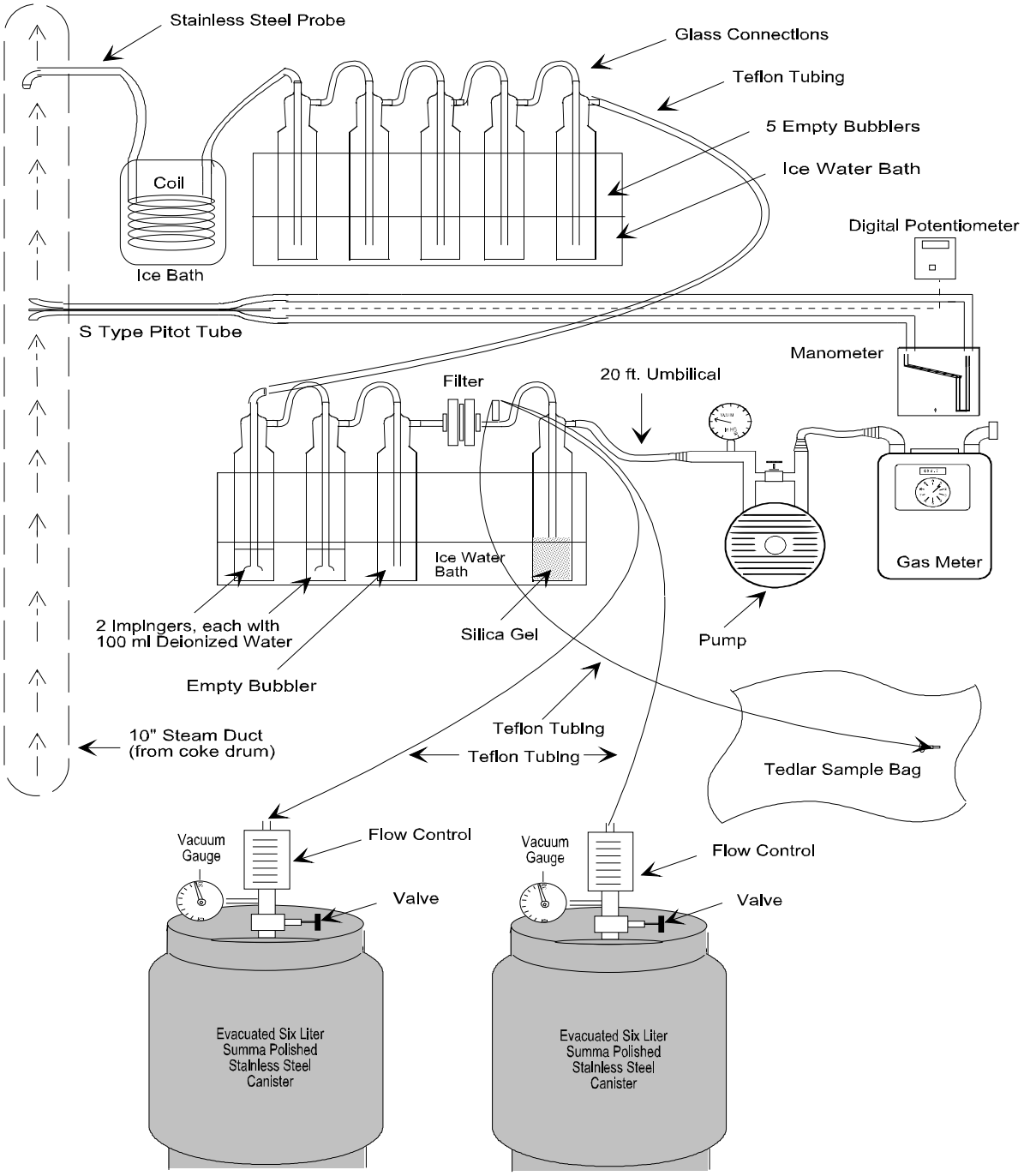


**Figure 2**
**Sampling Set-up**

## ***TEST CRITIQUE***

Particulate matter testing deviated from the minimum sample volume requirement of SCAQMD Method 5.1. The steaming cycle lasted for seven minutes, and the blowdown cycle lasted for ninety-one minutes. Of the 12.07 cubic feet of total volume sampled during steaming, 2.961 cubic feet (2.842 dscf) consisted of dry gas. 75.46 percent of the volume sampled was moisture. Of the 27 cubic feet of total volume sampled during blowdown, 0.619 cubic feet (0.589 dscf) consisted of dry gas. 97.71 percent of the volume sampled was moisture. The wet volumes did not meet the minimum 30 cubic feet (corrected to standard conditions) required for a Method 5.1 test. This deviation is thought to have a negligible impact on the testing since the intent of a minimum sample volume is the collection of detectable quantities of particulate matter. The amounts of PM collected were well over the minimum quantity needed (approximately 5 mg) to be considered as detectable quantities of PM.

The results indicate that sulfur compound emissions exceeded the 500 ppm limit of SCAQMD rule 407(a)(2)(A) during the blowndown cycle.

The results indicate that particulate matter emissions exceeded the grain loading limits established under SCAQMD Rule 404 (a). According to Table 404(a), for a discharge volume of 883 dscfm or less, the maximum concentration of particulate matter allowed in the discharge gas (calculated as dry gas at standard conditions) is 0.196 gr/dscf. Test results show that the discharge volumes were 130 dscfm, with a particulate matter concentration of 2.63 gr/dscf for blowdown, and 332 dscfm, with a particulate matter concentration of 0.244 gr/dscf for steaming in the discharge gas. Although the test results should not be used for compliance purposes due to deviations from the test methods, the magnitude of exceedance for the blowdown test indicates there is credibility to the assertion that Rule 404 was violated.

The source testing for emissions from the coke drum was complicated by the high moisture content of the vented emissions and the inability to capture emissions during all steps of the batch process. Although the emissions are reported, the reported emissions reflect an inherent low bias due to these difficulties in conducting the source testing. As such, the emissions should be considered as greater than that reported. Furthermore, it can be assured that despite the discrepancies in the testing in terms of adherence to the test method requirements, the emissions are at least that which was reported.

The following are more specific explanations of the sources of low bias:

1. After the blow down period, the top drum head is removed and continues to remain open for a period of time longer than the vent period to allow further cooling. After cooling, the coke is cut from the drum. It was observed that emissions occurred during these events as indicated by a visible steam. These emissions were not tested nor included in the **Results** section of this report. Based on observation of these plumes, these emissions may be significant.

2. A sample for sulfur was taken and analyzed. The sample was taken after the Method 5.1 train, which would have knocked out the soluble sulfur compounds including hydrogen sulfide. This loss was confirmed by the presence of soluble sulfates in the Method 5.1 sample.

## *CALCULATIONS*

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
21865 E. Copley Dr. Diamond Bar, California 91765-4182

Test No. 06-0249 BP/ARCO Test Date: 8/2/06

SOURCE TEST CALCULATIONS

Sampling Location: Coker Drum #3 (Steaming)
Sample Train 7 Input by: C. Willoughby

SUMMARY

| | | | | | |
|---|---|---|---|---|---|
| A. Average Traverse Velocity | | | | 44.59 | fps |
| B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters) | | | | 83.36 | deg F |
| C. Gas Meter Correction Factor | | | | 0.9959 | |
| D. Average Orifice Pressure | | | | 0.40 | "$H_20$ |
| E. Nozzle Diameter | | | | 0.1420 | inch |
| F. Stack Inside Diameter | 10 | inch | M. Pitot Correction Factor | 0.99 | |
| G. Stack Cross Sect. Area | 0.545 | ft2 | N. Sampling Time | 7.33 | min |
| H. Average Stack Temp | 198.7 | deg F | O. Nozzle X-Sect. Area | 0.00011 | ft |
| I. Barometric Pressure | 30.10 | "HgA | P. Net Sample Collection | 44.9 | mg |
| J. Gas Meter Pressure (I+(D/13.6)) | 30.13 | "HgA | Q. Net Solid Collection | 42.6 | mg |
| K. Static Pressure | 0.000 | "$H_20$ | R. Water Vapor Condensed | 188.3 | ml |
| L. Total Stack Pressure (I+(K/13.6)) | 30.10 | "HgA | S. Gas Volume Metered | 2.961 | dcf |

*Gas Vol. Mtrd. = (2.385 cf + (8.43 L x 0.0353 cf/L) + (564 torr/760 torr x 6 L x 0.0353 cf/L) + (435 torr/760 torr x 6 L x 0.0353 cf/L))*

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C | 2.842 | dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) | 75.46 | %

V. Average Molecular Weight (Wet):

| Component | Vol. Fract. | x | Moist. Fract. | x | Molecular Wt. | = | Wt./Mole |
|---|---|---|---|---|---|---|---|
| Water | 0.755 | | 1.000 | | 18.0 | , | 13.58 |
| Carbon Dioxide | 0.0006 | Dry Basis | 0.245 | | 44.0 | , | 0.01 |
| Carbon Monoxide | 0.0000 | Dry Basis | 0.245 | | 28.0 | , | 0.00 |
| Oxygen | 0.2050 | Dry Basis | 0.245 | | 32.0 | , | 1.61 |
| Nitrogen & Inerts | 0.794 | Dry Basis | 0.245 | | 28.2 | , | 5.50 |
| | | | | | | , | |
| | | | | | | Sum | 20.70 |

FLOW RATE

| | | | |
|---|---|---|---|
| W. Gas Density Correction Factor (28.95/V)^.5 | 1.18 | | |
| X. Velocity Pressure Correction Factor (29.92/L)^.5 | 1.00 | | |
| Y. Corrected Velocity (A x M x W x X) | 52.05 | fps | |
| Z. Flow Rate (Y x G x 60) | 1703 | cfm | |
| AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]} | 1353 | scfm | |
| BB. Dry Flow Rate (AA x (1-U/100)) | 332 | dscfm | |

SAMPLE CONCENTRATION/EMISSION RATE

| | | |
|---|---|---|
| CC. Sample Concentration [0.01543 x (P/T)] | 0.244 | gr/dscf |
| DD. Sample Concentration [54,143xCC/ (Molecular Wt.)] | #DIV/0! | ppm |
| EE. Sample Emission Rate (0.00857 x BB xCC) | 0.694 | lb/hr |
| FF. Solid Emission Rate [(.0001322 x Q x BB)/T] | 0.658 | lb/hr |
| GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)] | 579 | % |

| | | |
|---|---|---|
| **Steaming** | | |
| A. Probe Catch | 0 | mg |
| B. (1) Probe Acid | 0 | mg |
| (2) Probe Sulfate | 0 | mg |
| | | |
| C. Filter Catch | 0 | mg |
| D. (1) Filter Acid | 0 | mg |
| (2) Filter Sulfate | 0 | mg |
| | | |
| E. Impinger Catch | 42.6 | mg |
| F. (1) Impinger Acid | 0 | mg |
| (2) Impinger Sulfate | 53.8 | mg |
| | | |
| G. Impinger Organic | 2.3 | mg |
| | | |
| H. Total Particulate (A - B* + C - D* + E - F* + G) | 44.9 | mg |
| | | |
| I. Solid Particulate (F - B* - D* - G) | 42.6 | mg |
| | | |
| * Use Lower of (1) amd (2) | | |
| | | |

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
21865 Copley Drive, Diamond Bar, CA 91765

Test No: 06-249 -20- Date: 8/2 & 8/2006

| Traverse Point # | Velocity Head #1 ("$H_2O$) | Temp. ($^oF$) | Calculated Velocity (fps) | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 0.880 | 175 | 68.55 | | | | |
| 2 | 0.730 | 178 | 62.58 | | | | |
| 3 | 0.660 | 185 | 59.83 | | | | |
| 4 | 0.600 | 192 | 57.36 | | | | |
| 5 | 0.590 | 194 | 56.97 | | | | |
| 6 | 0.530 | 199 | 54.20 | | | | |
| 7 | 0.470 | 200 | 51.08 | | | | |
| 8 | 0.420 | 200 | 48.28 | | | | |
| 9 | 0.680 | 205 | 61.67 | | | | |
| 10 | 0.220 | 208 | 35.16 | | | | |
| 11 | 0.120 | 210 | 26.00 | | | | |
| 12 | 0.080 | 210 | 21.23 | | | | |
| 13 | 0.020 | 213 | 10.64 | | | | |
| 14 | 0.020 | 213 | 10.64 | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 17 | | | | | | | |
| 18 | | | | | | | |
| 19 | | | | | | | |
| 20 | | | | | | | |
| 21 | | | | | | | |
| 22 | | | | | | | |
| 23 | | | | | | | |
| 24 | | | | | | | |
| | 0.430 | 198.7 | 44.59 | | | | |
| Average Temperature ($^oF$) - | | 199 | Average Velocity (fps) - | | | | 44.59 |

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
21865 E. Copley Dr. Diamond Bar, California 91765-4182

Test No. 06-0249 BP/ARCO Test Date: 8/8/06

SOURCE TEST CALCULATIONS

Sampling Location: Coker Drum #2 (Blowdown)
Sample Tra 18 Input by: C. Willoughby

SUMMARY

| | | | | | |
|---|---|---|---|---|---|
| A. Average Traverse Velocity | | | | 180.37 | fps |
| B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters) | | | | 80.97 | deg F |
| C. Gas Meter Correction Factor | | | | 0.9959 | |
| D. Average Orifice Pressure | | | | 0.00 | "$H_20$ |
| E. Nozzle Diameter | | | | 0.1420 | inch |
| F. Stack Inside Diameter | 10 | inch | M. Pitot Correction Factor | 0.99 | |
| G. Stack Cross Sect. Area | 0.545 | ft2 | N. Sampling Time | 24 | min |
| H. Average Stack Temp | 217.4 | deg F | O. Nozzle X-Sect. Area | 0.00011 | ft |
| I. Barometric Pressure | 29.75 | "HgA | P. Net Sample Collection | 100.4 | mg |
| J. Gas Meter Pressure (I+(D/13.6)) | 29.75 | "HgA | Q. Net Solid Collection | 85.4 | mg |
| K. Static Pressure | 0.000 | "$H_20$ | R. Water Vapor Condensed | 542.9 | ml |
| L. Total Stack Pressure (I+(K/13.6)) | 29.75 | "HgA | S. Gas Volume Metered | 0.619 | dcf |

***Gas Vol. Mtrd. = (0.086 cf + (7.52 L x 0.0353 cf/L) + (552 torr/760 torr x 6 L x 0.0353 cf/L) + (405 torr/760 torr x 6 L x 0.0353 cf/L))***

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C 0.589 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) 97.71 %

V. Average Molecular Weight (Wet):

| Component | Vol. Fract. | x | Moist. Fract. | x | Molecular Wt. | = | Wt./Mole |
|---|---|---|---|---|---|---|---|
| Water | 0.9771 | | 1.000 | | 18.0 | , | 17.59 |
| Carbon Dioxide | 0.0091 | Dry Basis | 0.023 | | 44.0 | , | 0.01 |
| Carbon Monoxide | 0.0010 | Dry Basis | 0.023 | | 28.0 | , | 0.00 |
| Oxygen | 0.0700 | Dry Basis | 0.023 | | 32.0 | , | 0.05 |
| Hydrogen | 0.2715 | Dry Basis | 0.023 | | 2.0 | , | 0.01 |
| Methane | 0.3305 | Dry Basis | 0.023 | | 16.0 | , | 0.12 |
| Nitrogen & Inerts | 0.3179 | Dry Basis | 0.023 | | 28.2 | , | 0.20 |
| | | | | | | , | |
| | | | | | | Sum | 17.99 |

FLOW RATE

| | | |
|---|---|---|
| W. Gas Density Correction Factor (28.95/V)^.5 | 1.27 | |
| X. Velocity Pressure Correction Factor (29.92/L)^.5 | 1.00 | |
| Y. Corrected Velocity (A x M x W x X) | 227.18 | fps |
| Z. Flow Rate (Y x G x 60) | 7434 | cfm |
| AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]} | 5675 | scfm |
| BB. Dry Flow Rate (AA x (1-U/100)) | 130 | dscfm |

SAMPLE CONCENTRATION/EMISSION RATE

| | | |
|---|---|---|
| CC. Sample Concentration [0.01543 x (P/T)] | 2.629 | gr/dscf |
| DD. Sample Concentration [54,143xCC/ (Molecular Wt.)] | #DIV/0! | ppm |
| EE. Sample Emission Rate (0.00857 x BB xCC) | 2.922 | lb/hr |
| FF. Solid Emission Rate [(.0001322 x Q x BB)/T] | 2.485 | lb/hr |
| GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)] | 93.9 | % |

| | | |
|---|---|---|
| **Blowdown** | | |
| A. Probe Catch | 0 | mg |
| B. (1) Probe Acid | 0 | mg |
| (2) Probe Sulfate | 0 | mg |
| | | |
| C. Filter Catch | 0 | mg |
| D. (1) Filter Acid | 0 | mg |
| (2) Filter Sulfate | 0 | mg |
| | | |
| E. Impinger Catch | 85.4 | mg |
| F. (1) Impinger Acid | 0 | mg |
| (2) Impinger Sulfate | 50.9 | mg |
| | | |
| G. Impinger Organic | 15 | mg |
| | | |
| H. Total Particulate (A - B* + C - D* + E - F* + G) | 100.4 | mg |
| | | |
| I. Solid Particulate (F - B* - D* - G) | 85.4 | mg |
| | | |
| * Use Lower of (1) amd (2) | | |
| | | |

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
21865 Copley Drive, Diamond Bar, CA 91765

Test No: 06-249 -23- Date: 8/2 & 8/2006

| Traverse Point # | Velocity Head #1 ("$H_2O$) | Temp. ($^oF$) | Calculated Velocity (fps) | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 8.500 | 223 | 220.96 | | | | |
| 2 | 10.500 | 221 | 245.23 | | | | |
| 3 | 7.300 | 215 | 203.57 | | | | |
| 4 | 6.500 | 215 | 192.09 | | | | |
| 5 | 5.500 | 215 | 176.70 | | | | |
| 6 | 6.800 | 215 | 196.47 | | | | |
| 7 | 5.500 | 215 | 176.70 | | | | |
| 8 | 4.300 | 215 | 156.24 | | | | |
| 9 | 7.000 | 218 | 199.78 | | | | |
| 10 | 7.500 | 218 | 206.80 | | | | |
| 11 | 7.500 | 220 | 207.10 | | | | |
| 12 | 5.000 | 220 | 169.10 | | | | |
| 13 | 4.300 | 222 | 157.05 | | | | |
| 14 | 3.500 | 215 | 140.96 | | | | |
| 15 | 3.000 | 216 | 130.60 | | | | |
| 16 | 2.000 | 215 | 106.55 | | | | |
| 17 | | | | | | | |
| 18 | | | | | | | |
| 19 | | | | | | | |
| 20 | | | | | | | |
| 21 | | | | | | | |
| 22 | | | | | | | |
| 23 | | | | | | | |
| 24 | | | | | | | |
| | 5.919 | 217.4 | 180.37 | | | | |

Average Temperature ($^oF$) - 217 Average Velocity (fps) - 180.37

***MASS RATE CALCULATIONS (TANK NO. 54180) {BLOWDOWN}***

| Pollutant | Concentration (ppm) | Molecular Weight (lb/lb-mol) | Flow Rate (dscfm) | Mass Rate (lb/hr) |
|---|---|---|---|---|
| NM/NEOC, ppmC | 10000 | 14.3 | 130 | 2.942797 |
| Methane, ppm | 34.6 | 16 | 130 | 0.011393 |
| Ethane, ppmC | 29800 | 15 | 130 | 9.198813 |
| $C_{3, ppm}$ | 470 | 44 | 130 | 0.425574 |
| $C_{4, ppm}$ | 68.4 | 58 | 130 | 0.081641 |
| $C_{5, ppm}$ | 32.3 | 72 | 130 | 0.047859 |
| $C_{6, ppm}$ | 14.4 | 86 | 130 | 0.025485 |
| $C_{7, ppm}$ | 328 | 100 | 130 | 0.674991 |
| $C_{8, ppm}$ | 399 | 114 | 130 | 0.936056 |
| $C_{9}$-$C_{12, ppm}$ | 242 | 149 | 130 | 0.742038 |
| Benzene, ppm | 379 | 78 | 130 | 0.60836 |
| Toluene, ppm | 461 | 92 | 130 | 0.87280 |
| m + p - Xylene, ppm | 171 | 106 | 130 | 0.37301 |
| o-Xylene, ppm | 22.1 | 106 | 130 | 0.04821 |
| Ethylbenzene, ppm | 14.8 | 106 | 130 | 0.03228 |
| CO, ppm | 1080 | 28 | 130 | 0.62231 |
| $CO_{2, ppm}$ | 9280 | 44 | 130 | 8.40282 |

**Where: Mass Rate = $1.583 \times 10^{-7}$ x MW x ppm x Flow Rate**
**Molecular Weight of NM/NEOC taken as Hexane**

***MASS RATE CALCULATIONS (DUPLICATE RUN TANK NO. P4M3) {BLOWDOWN}***

| Pollutant | Concentration (ppm) | Molecular Weight (lb/lb-mol) | Flow Rate (dscfm) | Mass Rate (lb/hr) |
|---|---|---|---|---|
| NM/NEOC, ppmC | 9840 | 14.3 | 130 | 2.895712 |
| Methane, ppm | 31.5 | 16 | 130 | 0.010372 |
| Ethane, ppmC | 27300 | 15 | 130 | 8.427101 |
| $C_{3, ppm}$ | 464 | 44 | 130 | 0.420141 |
| $C_{4, ppm}$ | 67.8 | 58 | 130 | 0.080925 |
| $C_{5, ppm}$ | 31.3 | 72 | 130 | 0.046377 |
| $C_{6, ppm}$ | 13.4 | 86 | 130 | 0.023715 |
| $C_{7, ppm}$ | 341 | 100 | 130 | 0.701744 |
| $C_{8, ppm}$ | 418 | 114 | 130 | 0.980631 |
| $C_9$-$C_{12, ppm}$ | 253 | 149 | 130 | 0.775767 |
| Benzene, ppm | 393 | 78 | 130 | 0.63083 |
| Toluene, ppm | 481 | 92 | 130 | 0.91066 |
| m + p - Xylene, ppm | 177 | 106 | 130 | 0.38610 |
| o-Xylene, ppm | 18.7 | 106 | 130 | 0.04079 |
| Ethylbenzene, ppm | 12.7 | 106 | 130 | 0.02770 |
| CO, ppm | 978 | 28 | 130 | 0.56354 |
| $CO_{2, ppm}$ | 8890 | 44 | 130 | 8.04968 |

**Where: Mass Rate = $1.583 \times 10^{-7}$ x MW x ppm x Flow Rate**
**Molecular Weight of NM/NEOC taken as Hexane**

## *MASS RATE CALCULATIONS (AVERAGE OF TANK NOS. 54180 & P4M3)*

| Pollutant | Concentration (ppm) | Molecular Weight (lb/lb-mol) | Flow Rate (dscfm) | Mass Rate (lb/hr) |
|---|---|---|---|---|
| NM/NEOC, ppmC | 9920 | 14.3 | 130 | 2.919255 |
| Methane, ppm | 33.05 | 16 | 130 | 0.010882 |
| Ethane, ppmC | 28550 | 15 | 130 | 8.812957 |
| $C_{3, ppm}$ | 467 | 44 | 130 | 0.422857 |
| $C_{4, ppm}$ | 68.1 | 58 | 130 | 0.081283 |
| $C_{5, ppm}$ | 31.8 | 72 | 130 | 0.047118 |
| $C_{6, ppm}$ | 13.9 | 86 | 130 | 0.024600 |
| $C_{7, ppm}$ | 334.5 | 100 | 130 | 0.688368 |
| $C_{8, ppm}$ | 408.5 | 114 | 130 | 0.958343 |
| $C_{9}$-$C_{12, ppm}$ | 247.5 | 149 | 130 | 0.758902 |
| Benzene, ppm | 386 | 78 | 130 | 0.61959 |
| Toluene, ppm | 471 | 92 | 130 | 0.89173 |
| m + p - Xylene, ppm | 174 | 106 | 130 | 0.37956 |
| o-Xylene, ppm | 20.4 | 106 | 130 | 0.04450 |
| Ethylbenzene, ppm | 13.75 | 106 | 130 | 0.02999 |
| CO, ppm | 1029 | 28 | 130 | 0.59292 |
| $CO_{2, ppm}$ | 9085 | 44 | 130 | 8.22625 |

**Where: Mass Rate = $1.583 \times 10^{-7}$ x MW x ppm x Flow Rate**
**Molecular Weight of NM/NEOC taken as Hexane**

***MASS RATE CALCULATIONS (TANK NO. 54154) {STEAMING}***

| Pollutant | Concentration (ppm) | Molecular Weight (lb/lb-mol) | Flow Rate (dscfm) | Mass Rate (lb/hr) |
|---|---|---|---|---|
| NM/NEOC, ppmC | 12 | 14.3 | 332 | 0.009019 |
| Methane, ppm | 8 | 16 | 332 | 0.006727 |
| Ethane, ppmC | 2 | 15 | 332 | 0.001577 |
| $C_{3, ppm}$ | 0.4 | 44 | 332 | 0.000925 |
| $C_{4, ppm}$ | 0.3 | 58 | 332 | 0.000914 |
| $C_{5, ppm}$ | 0.2 | 72 | 332 | 0.000757 |
| $C_{6, ppm}$ | 0.2 | 86 | 332 | 0.000904 |
| $C_{7, ppm}$ | 0.3 | 100 | 332 | 0.001577 |
| $C_{8, ppm}$ | 0.3 | 114 | 332 | 0.001797 |
| $C_{9}$-$C_{12, ppm}$ | 1 | 149 | 332 | 0.007831 |
| Benzene, ppm | 0.1 | 78 | 332 | 0.00041 |
| Toluene, ppm | 0.1 | 92 | 332 | 0.00048 |
| m + p - Xylene, ppm | 0.1 | 106 | 332 | 0.00056 |
| o-Xylene, ppm | 0.1 | 106 | 332 | 0.00056 |
| Ethylbenzene, ppm | 0.1 | 106 | 332 | 0.00056 |
| CO, ppm | 2 | 28 | 332 | 0.00294 |
| $CO_{2, ppm}$ | 641 | 44 | 332 | 1.48228 |

**Where: Mass Rate = $1.583 \times 10^{-7}$ x MW x ppm x Flow Rate**
**Molecular Weight of NM/NEOC taken as Hexane**

***MASS RATE CALCULATIONS (DUPLICATE RUN TANK NO. 54209) {STEAMING}***

| Pollutant | Concentration (ppm) | Molecular Weight (lb/lb-mol) | Flow Rate (dscfm) | Mass Rate (lb/hr) |
|---|---|---|---|---|
| NM/NEOC, ppmC | 9 | 14.3 | 332 | 0.006764 |
| Methane, ppm | 4 | 16 | 332 | 0.003364 |
| Ethane, ppmC | 1 | 15 | 332 | 0.000788 |
| $C_{3, ppm}$ | 0.2 | 44 | 332 | 0.000462 |
| $C_{4, ppm}$ | 0.1 | 58 | 332 | 0.000305 |
| $C_{5, ppm}$ | 0.1 | 72 | 332 | 0.000378 |
| $C_{6, ppm}$ | 0.2 | 86 | 332 | 0.000904 |
| $C_{7, ppm}$ | 0.2 | 100 | 332 | 0.001051 |
| $C_{8, ppm}$ | 0.2 | 114 | 332 | 0.001198 |
| $C_9$-$C_{12, ppm}$ | 0.4 | 149 | 332 | 0.003132 |
| Benzene, ppm | 0.1 | 78 | 332 | 0.00041 |
| Toluene, ppm | 0.1 | 92 | 332 | 0.00048 |
| m + p - Xylene, ppm | 0.1 | 106 | 332 | 0.00056 |
| o-Xylene, ppm | 0.1 | 106 | 332 | 0.00056 |
| Ethylbenzene, ppm | 0.1 | 106 | 332 | 0.00056 |
| CO, ppm | 1 | 28 | 332 | 0.00147 |
| $CO_{2, ppm}$ | 579 | 44 | 332 | 1.33891 |

**Where: Mass Rate = $1.583 \times 10^{-7}$ x MW x ppm x Flow Rate**
**Molecular Weight of NM/NEOC taken as Hexane**

## *MASS RATE CALCULATIONS (AVERAGE OF TANK NOS. 54154 & 54209)*

| Pollutant | Concentration (ppm) | Molecular Weight (lb/lb-mol) | Flow Rate (dscfm) | Mass Rate (lb/hr) |
|---|---|---|---|---|
| NM/NEOC, ppmC | 10.5 | 14.3 | 332 | 0.007891 |
| Methane, ppm | 6 | 16 | 332 | 0.005045 |
| Ethane, ppmC | 1.5 | 15 | 332 | 0.001183 |
| $C_{3, ppm}$ | 0.3 | 44 | 332 | 0.000694 |
| $C_{4, ppm}$ | 0.2 | 58 | 332 | 0.000610 |
| $C_{5, ppm}$ | 0.15 | 72 | 332 | 0.000568 |
| $C_{6, ppm}$ | 0.2 | 86 | 332 | 0.000904 |
| $C_{7, ppm}$ | 0.25 | 100 | 332 | 0.001314 |
| $C_{8, ppm}$ | 0.25 | 114 | 332 | 0.001498 |
| $C_{9}$-$C_{12, ppm}$ | 0.7 | 149 | 332 | 0.005482 |
| Benzene, ppm | 0.1 | 78 | 332 | 0.00041 |
| Toluene, ppm | 0.1 | 92 | 332 | 0.00048 |
| m + p - Xylene, ppm | 0.1 | 106 | 332 | 0.00056 |
| o-Xylene, ppm | 0.1 | 106 | 332 | 0.00056 |
| Ethylbenzene, ppm | 0.1 | 106 | 332 | 0.00056 |
| CO, ppm | 1.5 | 28 | 332 | 0.00221 |
| $CO_{2, ppm}$ | 610 | 44 | 332 | 1.41059 |

**Where: Mass Rate = $1.583 \times 10^{-7}$ x MW x ppm x Flow Rate**
**Molecular Weight of NM/NEOC taken as Hexane**

***MASS RATE CALCULATIONS (TEDLAR BAG NO. 1) {BLOW DOWN}***

| Pollutant | Concentration* (ppm) | Molecular Weight (lb/lb-mol) | Flow Rate (dscfm) | Mass Rate* (lb/hr) |
|---|---|---|---|---|
| Hydrogen Sulfide | 7680 | 34 | 130 | 5.374 |
| Carbonyl Sulfide | 18 | 60 | 130 | 0.022 |
| Methyl Mercaptan | 6 | 48 | 130 | 0.006 |
| Ethyl Mercaptan | 1 | 62 | 130 | 0.001 |
| Dimethyl Sulfide | 0.1 | 62 | 130 | 0.000 |
| Isopropyl Mercaptan | 0.1 | 76 | 130 | 0.000 |
| n-Propyl Mercaptan | 0.1 | 76 | 130 | 0.000 |
| Unknown Sulfur | 2.89 | 34 | 130 | 0.002 |
| | | | | |
| Total Sulfur* | 7708 | 34 | 130 | 5.393 |

**Where: Mass Rate = $1.583 \times 10^{-7}$ x MW x ppm x Flow Rate**

***Reported as $H_2S$ and as less than the values indicated**

***MASS RATE CALCULATIONS (TEDLAR BAG NO. 2) {STEAMING}***

| Pollutant | Concentration* (ppb) | Molecular Weight (lb/lb-mol) | Flow Rate (dscfm) | Mass Rate* (lb/hr) |
|---|---|---|---|---|
| Hydrogen Sulfide | 60.1 | 34 | 332 | 0.00010739 |
| Carbonyl Sulfide | 5.3 | 60 | 332 | 0.00001671 |
| Methyl Mercaptan | 1.1 | 48 | 332 | 0.00000277 |
| Ethyl Mercaptan | 1.3 | 62 | 332 | 0.00000424 |
| Dimethyl Sulfide | 0.1 | 62 | 332 | 0.00000033 |
| Isopropyl Mercaptan | 2.4 | 76 | 332 | 0.00000959 |
| n-Propyl Mercaptan | 0.1 | 76 | 332 | 0.00000040 |
| Unknown Sulfur | 0.1 | 34 | 332 | 0.00000018 |
| | | | | |
| Total Sulfur* | 70.1 | 34 | 332 | 0.00012526 |

**Where: Mass Rate = $1.583 \times 10^{-7}$ x MW x (ppb/1000) x Flow Rate**

***Reported as $H_2S$ and as less than the values indicated**

***CALCULATIONS: MASS EMISSIONS PER SINGLE BLOWDOWN EVENT (TABLE NO. 2)***

- Solid PM by Method 5.1 = solid PM emission rate x emission time
  = 2.485 lb/hr x 91 minutes x 1 hr ÷ 60 minutes
  = 3.77 lb

- Condensable Organic PM/VOC = (impinger catch insolubles + organic residue)
  x (dry flow rate ÷ corrected gas volume)
  x emission time
  = (15) mg x 1 lb/(453.593 x 1000 mg)
  x (130 dscfm ÷ 0.589 dscf)
  x 91 minutes
  = 0.66 lb

- Gaseous VOC as Hexane = concentration ppmv ÷ 10^6 x dry flow rate
  ÷ 379.46 $ft^3$/lbmol x 14.36 lb/lbmol
  x emission time
  = 9,920 ppmv ÷ 10^6 x 130 dscfm
  ÷ 379.46 $ft^3$/lbmol x 14.36 lb/lbmol
  x 91 minutes
  = 4.44 lb

- Sulfur Compound as $H_2S$ = mass emission rate x emission time
  = 5.393 lb/hr x 91 minutes x 1 hr ÷ 60 minutes
  = 8.18 lb

## *CALCULATIONS: MASS EMISSIONS PER SINGLE STEAMING EVENT (TABLE NO. 4)*

- Solid PM by Method 5.1 = solid PM emission rate x emission time
  = 0.658 lb/hr x 7.33 minutes x 1 hr ÷ 60 minutes
  = 0.080 lb

- Condensable Organic PM/VOC = (impinger catch insolubles + organic residue)
  x (dry flow rate ÷ corrected gas volume)
  x emission time
  = (2.3) mg x 1 lb/(453.593 x 1000 mg)
  x (332 dscfm ÷ 2.842 dscf)
  x 7.33 minutes
  = 0.0043 lb

- Gaseous VOC as Hexane = concentration ppmv ÷ 10^6 x dry flow rate
  ÷ 379.46 $ft^3$/lbmol x 14.36 lb/lbmol
  x emission time
  = 10.5 ppmv ÷ 10^6 x 332 dscfm
  ÷ 379.46 $ft^3$/lbmol x 14.36 lb/lbmol
  x 7.33 minutes
  = 0.00097 lb

- Sulfur Compound as $H_2S$ = mass emission rate x emission time
  = 0.000125 lb/hr x 7.33 minutes x 1 hr ÷ 60 minutes
  = 0.000015 lb

# APPENDIX

## FIELD DATA, FIELD NOTES, CALIBRATION, LABORATORY RESULTS